§16. Installation and Initial Measurements of the Divertor Interferometer on LHD

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Divertor detachment is one of the preferable operations in future fusion reactors because it can significantly reduce the heat load to divertor plates. In order to understand physics of the divertor plasma during the detachment, information of the electron density of the divertor legs with a high temporal resolution is indispensable.

So far, there was no interferometr which measures the divertor plasma, while the 13ch FIR laser interferomerter and the CO_2 laser imaging interferometer have been operated routingly for a core plasma. Hence we installed a millimeter-wave heterodyne interferomerter in LHD as shown in Fig.1 before the 11th operational campaign. The frequency of a probe beam is 67 GHz. The over-sized and circular waveguides were installed in 3-O port. A reflection plate is used to make the millimeter wave double path. The measured position of the diverter leg is at the middle point between the X-point and diverter plates. The temporal resolution is 10 μs and the present density resolution is $\pm 2.3\times10^{16}$ m^{-3}.

Figure 2 shows temporal behaviors of the divertor density during the detachment operations. The amount of puffed gas to make the peripheral plasma cool and detach was increased from discharge (a) to (c). At discharge (a), the divertor plasma did not detach due to running short of the puffed gas. The detachment occurred by increasing the gas puffing at discharge (b), but it promptly attached again. Further increasing of the amount of the gas realized the detachment plasma for 1.5 seconds at the discharge (c). During the detachment, the density at the measurement position of the divertor interferometer decreased down to about half. This means that detachment condition spreads up to upper stream, not only near the divertor plates. The divertor density decreases in two step when the plasma move to the detachment condition. The density decreases gradually for several tens ms, and then it drops with a time constant of about 1 ms. This transient response is expected to reflect the mechanism of the detachment.

It is reported that Core Density Collapse (CDC) in a SDC/IDB plasma limit increase in the density and the stored energy. In addition to that, small flush of the particles, which also reduce the stored energy, is observed with the divertor interferometer as shown in Fig.3. The stored energy gradually increases after pellet injections. However, it decreases just after bursts of the divertor density. This suggests that pressure-driven instabilities flush particles from the core to the divertor plasma. Though the decrease in the stored energy is smaller (several %) than that caused by the CDC (several tens %), this flushing phenomenon also limits the performance of the SDC/IDB plasma.

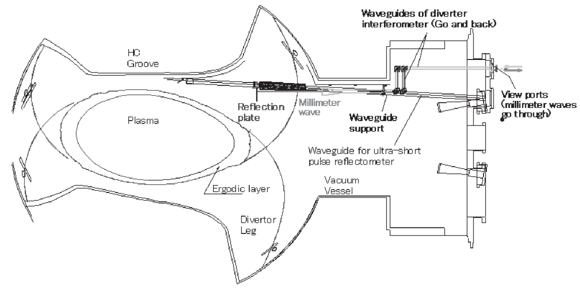

Fig.1: Schematic view of the diverter interferometer installed in LHD (3-O port).

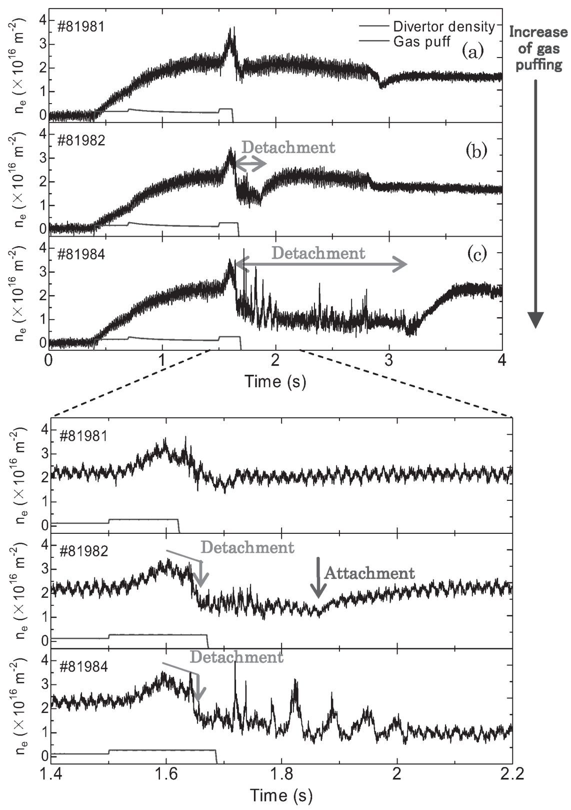

Fig. 2: Temporal behaviors of the divertor density during detachment operations.

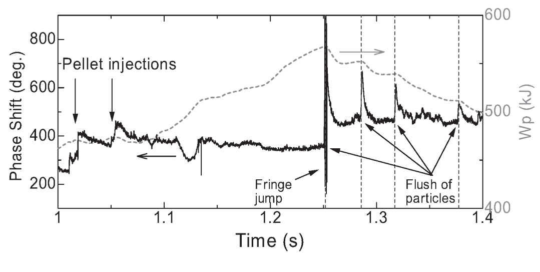

Fig.3: A Phase shift (proportional to the electron density) of the divertor interferometer at the maximum stored energy of SDC/IDB plasma. Intermittent flush of particles and resultant decrease in the stored energy is observed.